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# Increase of Durability Transmission Mechanism Based on the Laser Processing Improvement

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## Abstract

The method to increase the wearing capacity of the surface layer of construction machinery transmission parts is proposed. The method is based on the use of laser processing with rational modes. The optimal parameters of processing modes, depending on the type of coating are determined. The features of the surface layer hardening after laser processing are considered. The results of studies in laser processing, which allow achieving increased reliability of transmission construction machinery, high wearing capacity, corrosion resistance, fatigue strength and necessary structure of the surface layer are presented. The results showed that in the lower layers, heated to lower temperatures, the ferrite transformation is not complete and a little austenite is saturated with carbon. The features of the application researched and the optimal value of hardness and microstructure characteristics of the surface layer after laser processing are determined. The most rational modes of laser processing, which allow achieving the improvement of tribological characteristics of the transmission mechanism parts surfaces, that contributes towards increase their wearing capacity and durability are obtained.

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**Keywords:** laser processing; surface layer; microhardness; wearing capacity; radiation power.

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## 1. Introduction

The processing of continuous laser radiation is carried out at a certain speed of the scanning beam over the surface. With the increasing of power density and the decreasing of the relative speeds of the beam movement speed

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of cooling falls. As a result, the hardened structure is released and the hardness is decreased. The maximum hardness of the surface layer is achieved at a sufficiently high cooling rate [1-8].

However, at low speeds of the beam movement cause the increase of the depth of the hardened layer. Therefore, the laser processing modes is optimized depending to the required functional properties.

Most of the road construction machinery (RCM) is equipped with a manual transmission (gearboxes), which include the transmission control mechanism made in the form of a set of movable with the lever bars and packaged latches. The service life of the transmission control mechanism is determined by the number of inclusions, which under the existing technology of hardening the working surfaces of the clamp and strap a high-frequency currents (HFC) is up to 50 thousand inclusions (6 thousand hours of operation), which is insufficient.

## 2. Main part

There are many of constructive solutions that allow to change the effect of fixing the transmission control mechanism [2, 10]. Mostly these solutions are based on the change of cone angle in the direction of the decreasing or due to the replacement design of the locking mechanism. These changes in most cases lead to a change in the whole control mechanism (complete its replacement of a different design), which requires the inclusion in the production process of new technological operations, changing of equipment and increasing the costs [3, 9, 14]. It is known that the hardening of materials used for manufacturing dies tools, laser hardening with cyanidation gave positive results [4, 13, 15]. The recommended composition and processing modes: the coating - 25% of potassium ferrocyanide  $K_4Fe(CN)_6$ , a binder - BF6 glue diluted with acetone (20-25% by weight), the radiation energy of 12-16 Joules.

Therefore, the most rational approach is the application of laser processing for the transmission mechanism. The mode of laser processing mode is selected depending on the type of the laser used [5,16]. For example, for steel 45 are set as processing mode high-power  $CO_2$  – laser modes "SpectraPhysics", power 5 kW, under the following modes: the useful power  $W = 3,5-4$  kWh, the diameter of the laser spot  $d_L = 8$  mm, the speed of transportation of the laser beam  $V_{mod} = 0,4-0,7$  m/min., the density of the emission power  $q_0 = 30-53$  J/mm<sup>2</sup>, the absorption coefficient of laser radiation  $\eta_{ef} = 0,7$  [6]. The number of passes is 1.

As a result of the carried out research established the following modes of laser processing allowing to achieve increased productivity by technological installation, high wearing capacity, corrosion resistance, fatigue resistance and necessary structure of the surface layer:

Mode 1. The light-absorbing coating - red-brown gouache poster. The radiation power  $P = 900$  W, the diameter fingerprint  $D_f = 5,5$  mm, the feed speed (or processing)  $V = 15,7$  mm / sec.

Table 1. Mode 1.

The distance between the measuring points, micro-hardness, mm	The diagonal size of the diamond imprint, mkm	The value of microhardness HV, kg/mm <sup>3</sup>	Approximate translation HV values in HRC	Microstructure
0,1	58	572	52	Troostomartensit needle orientation, and then troostomartensit and troostitmartensitnaya grid, which goes into troostoferritnuyu and on the border with the original structure - in the ferrite
0,1	56	613	54	
0,1	59	554	51	
0,1	58	572	52	
0,15	56	613	54	
0,15	60	536	50	
0,15	63	488	47	
0,1	78	317	29	Ferrite on the limits of large grains of perlite (unnormalized structure)

Mode 2. The light-absorbing coating - red-brown gouache poster. The radiation power  $P = 900$  W, the diameter fingerprint  $D_f = 5,0$  mm, the feed speed (or processing)  $V = 4,6$  mm / sec.

Table 2. Mode 2.

The distance between the measuring points, microhardness, mm	The diagonal size of the diamond imprint, mkm	The value of microhardness HV, kg/mm <sup>3</sup>	Approximate translation HV values in HRC	Microstructure
0,1	57	592	53	Troostomartensit needle orientation (needle-like martensite 6-7 points)
0,1	58	572	52	
0,1	57	592	53	
0,2	59	554	51	Troostomartensit
0,2	58	572	52	
0,2	56	613	54	
0,1	59	554	51	Troostomartensit and rare small inclusions of ferrite
0,1	62	503	48	
0,1	65	456	45	
0,2	74	354	32	Ferrite on the limits of large grains of perlite (unnormalized structure)
0,2	84	274	35	
0,2	84	274	35	

In tables 1.1 and 1.2 presents the values of the hardness and microstructure characteristics of the surface after laser processing (mode 1, mode 2).

In the lower layers, heated to a lower temperature, the ferrite transformation is not complete and formed a little austenite is saturated with carbon. This leads to a significant decrease of the critical cooling rate and the formation of troostite, troostite-ferritic or ferritic-mesh.

The carbide surface is sensitive to the energy density. There are such optimal energy  $E_0$  is much less than the limit of radiation energy  $E_n$ , in which the surface of the workpiece of hard alloy no defects occur, leading to destruction [7, 11, 12]. For all values of energy located between  $E_n$  and  $E_0$ , i.e.  $E_0 < E < E_n$  at the surface of the workpiece of hard alloy can be created hidden defects that are not detected visually, but lead to significant deterioration in the working process of the tool [17-20]. The values of the energies  $E_n$  and  $E_0$  depend on the cobalt content in the alloy and the grain size.

Laser processing of working surfaces must be preceded by a trial of hardening non-working surfaces with subsequent verification of the hardened zone on defects under 10x magnification. Upon detection of defects such as microcracks density of processing energy must be reduced by 0,1-0,2 J/mm<sup>2</sup>.

### 3. Conclusions

The application of rational modes of laser processing blanks of steel and cast irons increases wearing capacity and microhardness parameters by 5-10% in comparison with existing traditional methods. Laser processing normalized or annealed steels is recommended at low speeds (less than 15 m/s) of the laser beam scanning. The same results are obtained when the laser processing transmission, working surfaces of the clamp and strap after quenching and high tempering.

Laser processing can effectively increase fretting resistance places of mates of machine parts. The increase in the amplitude of microscopic displacements leads to a parabolic dependence of wear on the carbon content in steel. For the original surface corresponds to the optimum steel with a carbon content of 0,7%. Laser processing of several shifts the point corresponding to minimum wear, in the direction of the reducing the carbon content of the

steel (to 0,5-0,6%). With the increasing load the contact area for increased wear becomes even more essential for all examined steels.

Thus, as a result of the research have been obtained the most rational modes of laser processing, which allow to achieve improvement of tribological characteristics of the surfaces of the parts transmission mechanism, that contributes towards increase their wearing capacity and durability.

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